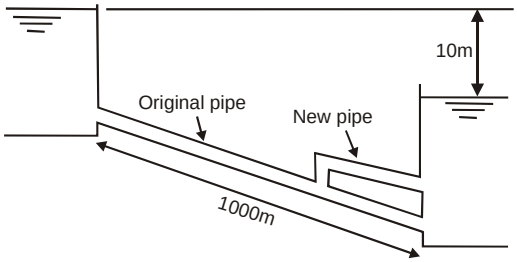
1.12.2 Other Pipe Flow Examples

1.12.2.1 Adding a parallel pipe example

A pipe joins two reservoirs whose head difference is 10m. The pipe is 0.2 m diameter, 1000m in length and has a f value of 0.008.

a) What is the flow in the pipeline?

b) It is required to increase the flow to the downstream reservoir by 30%. This is to be done adding a second pipe of the same diameter that connects at some point along the old pipe and runs down to the lower reservoir. Assuming the diameter and the friction factor are the same as the old pipe, how long should the new pipe be?



a)

$$h_f = \frac{fLQ^2}{3d^5}$$

$$10 = \frac{0.008 \times 1000 Q^2}{3 \times 0.2^5}$$

$$Q = 0.0346\, m^3/s$$

$$Q = 34.6\, litres/s$$

b)

$$H = 10 = h_{f1} + h_{f2} = h_{f1} + h_{f3}$$

$$\therefore$$

$$h_{f2} = h_{f3}$$

$$\frac{f_2 L_2 Q_2^{\,2}}{3d_2^{\,5}} = \frac{f_3 L_3 Q_3^{\,2}}{3d_3^{\,5}}$$

as the pipes 2 and 3 are the same f, same length and the same diameter then $Q_2 = Q_3$.

By continuity $Q_1 = Q_2 + Q_3 = 2Q_2 = 2Q_3$
So

$$Q_2 = \frac{Q_1}{2}$$

and

$$L_2 = 1000 - L_1$$

Then

$$10 = h_{f1} + h_{f2}$$

$$10 = \frac{f_1 L_1 Q_1^2}{2d_1^2} + \frac{f_2 L_2 Q_2^2}{2d_2^2}$$

$$10 = \frac{f_1 L_1 Q_1^2}{2d_1^2} + \frac{f_2 (1000 - L_1)(Q_1/2)^2}{2d_2^2}$$

As $f_1 = f_2$, $d_1 = d_2$

$$10 = \frac{f_1 Q_1^2}{3d_1^2}\left(L_1 + \frac{(1000 - L_1)}{4}\right)$$

The new Q_1 is to be 30% greater than before so $Q_1 = 1.3 \times 0.034 = 0.442$ m^3/s

Solve for L to give

$$L_1 = 455.6\text{m}$$

$$L_2 = 1000 - 455.6 = 544.4 \text{ m}$$